BIOLOGICAL EVALUATION OF GYPSY MOTH

AT

CHESAPEAKE MARSHLANDS NATIONAL WILDLIFE REFUGE COMPLEX, 2000-2001

Prepared by

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and

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ABSTRACT

On January 8-11, 2001, USDA Forest Service personnel conducted a gypsy moth egg mass survey at Chesapeake Marshlands National Wildlife Refuge Complex (CMNWRC) to evaluate the efficacy of the 2000 treatment areas and to assess the potential for defoliation and the need for treatment in 2001. Current populations are sufficient to cause noticeable defoliation on 1,709 acres. To protect Delmarva fox squirrel habitat, treatment is recommended in these areas in 2001.

METHODS

The survey area consisted of all areas that were treated in 2000 and in stands that were previously identified as being fair or good fox squirrel habitat with a high potential for gypsy moth defoliation (Whiteman and Onken, 1994). The survey was also conducted in stands acquired after 1994 that have a significant oak component. These new stands have a high potential for gypsy moth defoliation and are also considered as good fox squirrel habitat. The 44 stands that were surveyed are presented in Figure 1.

Within each stand, gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. The number of survey plots in each stand was dependent on the size of the stand. Thus, more survey plots were established in the larger stands. At each sample point, a 1/40th acre fixed radius plot was established. The plots consisted of a tally of all the new (2000) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre.

Egg mass length was measured at most of the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) were used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The location of the survey plots are shown in Figures 2a-2d and the survey results are summarized in Table 1. Overall egg mass densities ranged from 0-20,760 and averaged 1,292 egg masses per acre. Egg mass densities are sufficient to cause noticeable defoliation (31-100 percent) in Stands 3, 4, 10, 11, 12, 13, 27, 29, 33, 34, 35, 37, 51, 64, 66, 69, 70, 71, 72, 73, 74 and the southwestern portion of 7. Egg mass densities in Stands 1, 5, 6, 9, 21, 23, 32, 38, 39, 40, 41, 44, 56, 57, 58, 60, 61, 62, 63, 65, 67, 68 and the rest of 7 are not expected to cause noticeable defoliation. Egg mass lengths at CMNWRC averaged 30 mm, but varied greatly in the 44 surveyed stands ranging from 15-50 mm.

Egg mass survey results for the 7 stands (612 acres) treated in 2000 are summarized in Table 2. Overall, the average egg mass density was reduced 42 percent from the pre-treatment level of 1,973 to the current level (post-treatment) of 1,150 egg masses per acre. Egg mass densities were reduced by at least 75 percent in Stands 5, 6, 7, 9 and 39. Egg mass densities were reduced by 52 percent in Stand 51 and actually increased by 162 percent in the Stand 4. Of the 135 acres of defoliation that occurred at CMNWRC in 2000, 41 acres were in the treatment area. This amounts to only 7 percent of the treatment area. One hundred and thirty acres (21 percent) of the 2000 treatment area will need to be re-treated in 2001.

DISCUSSION

All stands surveyed are managed to preserve Delmarva fox squirrel habitat. Gypsy moth defoliation with subsequent mast reduction and potential tree mortality are likely to have a negative impact on the habitat quality of these stands.

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (1-30 percent); moderate (31-60 percent); and heavy (61-100 percent).

The survey results indicate that heavy defoliation is likely to occur on approximately 1,169 acres and moderate defoliation on 490 acres at CMNWRC in 2001.

This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity will increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 4 illustrates how this information can be used to correlate the predicted defoliation of Stand 13.

Accordingly, the estimated egg mass density of 2,887 egg masses per acre x 31 mm (average length of egg masses) in Stand 13 translates to a projected defoliation level of about 71 percent (heavy defoliation). Because egg mass densities and host type are not evenly distributed, actual defoliation will vary from tree to tree but will be predominately heavy throughout this stand. Table 3 shows the projected defoliation level for each of the surveyed stands.

Egg masses longer than 25 mm typically indicate healthy populations with no obvious stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining or stressed populations. It is possible that either the gypsy moth fungus or the NPV could cause the collapse of defoliating levels of gypsy moth, however, it is unlikely that populations will collapse prior to a significant defoliation event occurring in 2001.

Based on the existing egg mass densities and general size of egg masses, gypsy moth populations appear to be building and healthy in Stands 4, 12, 13, 29, 33, 34, 35, 37, 64, 66, 69, 70, 71, 72 and 74. Populations appear to be declining in Stands 3, 10, 11, 27, 51, 73 and the southwestern portion of 7 while populations are low to non-existent in Stands 1, 5, 6, 9, 21, 23, 32, 38, 39, 40, 41, 44, 56, 57, 58, 60, 61, 62, 63, 65, 67, 68 and the rest of 7. This variation in health and density is not uncommon when one considers that these stands are scattered and spread over several miles.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the

time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (< 60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of the potential tree mortality that can occur. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28) percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak sawtimber and 14 percent of the total oak poletimber occurred after one year of moderate to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality. The adequate rainfall received during the 2000 growing season should significantly reduce the amount of mortality caused by the 2000 gypsy moth defoliation. Extensive mortality is likely if a severe defoliation event occurs along with a dry growing season in 2001, particularly in the areas defoliated both years.

Gypsy moth defoliation also has a significant impact on mast production. The potential loss of acorn mast was demonstrated by McConnell in 1988 (Gottschalk, 1990). His study found that moderate defoliation reduced production by about 50 percent and heavy defoliation near 100 percent. Other studies conducted by the Pennsylvania Game Commission had similar results and found that reduced acorn production continued for 1-2 years following the last year of defoliation.

Management Options

For 2001, two management options have been evaluated for managing defoliating levels of gypsy moth populations on 1,709 acres at CMNWRC. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage on 80 percent of the area in order to prevent mast failure and tree mortality; and 2) reduce gypsy moth population below the treatment threshold on 80 percent of the area. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating level gypsy moth populations (greater than 750 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels. Although it is not possible to accurately assess such events with the

information at hand, it is unlikely that a collapse will occur prior to an extensive defoliation event in 2001.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al. (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that widespread moderate and heavy defoliation will occur at CMNWRC in 2001 and gypsy moth will spread into stands at that are currently uninfested.

Microbial Insecticide Option

***Btk*:** The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (Btk)*. This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al. (1996) in West Virginia. Miller's study involved a large-scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1-year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available

commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection can be achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 2×10^{11} occlusion bodies (OB's) per acre applied in two applications, 3-5 days apart. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments.

Alternatives

With the previously described options in mind, the following alternatives are offered.

Alternative 1.	-No action
Alternative 2.	-One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ¾ gallon per acre.
Alternative 3	-Two aerial applications of *Btk*, as in alternative 2, applied 4-7 days apart.
Alternative 4	-Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.

RECOMMENDATIONS

As previously stated, gypsy moth populations at CMNWRC are sufficient to cause widespread moderate and heavy defoliation in 2001. In order to protect tree foliage, mast production and prevent subsequent tree mortality, the recommendation is to implement Alternative 2 (a single application of Btk) on 270 acres and Alternative 3 (a double application of Btk) on 1,439 acres

(Figure 5). The single application of Btk is to be applied in Stands 3, 10, 11, 27, 51, 69, 73 and the south western portion of 7. The double application of Btk is to be applied in stands 4, 12, 13, 29, 33, 34, 35, 37, 64, 66, 70, 71, 72 and 74.

Only small and scattered areas of defoliation, if any, are expected elsewhere at CMNWRC in 2001.

Alternative 2 on 270 acres and Alternative 3 on 1,439 acres are recommended based on the following considerations.

1) A single application of Btk will provide foliage protection and a population reduction in areas where populations appear to be declining but densities are sufficient to cause defoliation.

2) A double application of Btk is likely to provide both a population reduction and foliage protection in areas where populations are high and appear to be building.

3) A double application of Gypchek on all 1709 acres is likely to provide some foliage protection but significant reductions in population levels below treatment thresholds is not likely to occur in areas with building gypsy moth populations.

4) The cost of a single application of Btk on 270 acres and a double application of Btk on 1439 acres is more economical than a double application of Gypchek on all 1709 acres in terms of both insecticide material and application costs.

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Table 1 – Gypsy Moth egg mass survey results at Chesapeake Marshland NWR Complex, January 8-11, 2001.

Stand 1

Plot Number	Number EM/acre
1	0
2	0
3	160
EM/acre range = 0-160 EM/acre average = 53	EM size range (mm) = 30-35 EM size average (mm) = 32

Stand 3

Plot Number	Number EM/acre
4	1,720
5	0
EM/acre range = 0-1,720 EM/acre average = 860	EM size range (mm) = 25-40 EM size average (mm) = 32

Stand 4

Plot Number	Number EM/acre	Plot Number	Number EM/acre
6	240	9	20,760
7	0	10	5,440
8	3,040		
EM/acre range = 0-20,760 EM/acre average = 5896		EM size range (mm) = 15-30 EM size average (mm) = 24	

Stand 5

Plot Number	Number EM/acre
11	80
12	0
13	0
EM/acre range = 0-80 EM/acre average = 27	EM size range (mm) = 30-50 EM size average (mm) = 40

Stand 6

Plot Number	Number EM/acre	Plot Number	Number EM/acre
14	0	17	240
15	600	18	0
16	0		
EM/acre range = 0-600 EM/acre average = 168		EM size range (mm) = 15-35 EM size average (mm) = 24	

Stand 7

Plot Number	Number EM/acre	Plot Number	Number EM/acre
19	0	21	0
20	0	22*	1,480
EM/acre range = 0-1,480 EM/acre average = 370		EM size range (mm) = 30-35 EM size average (mm) = 32	

EM/acre average in portion of stand recommend for treatment = 1,480
* denotes plot is located in portion of stand recommended for treatment

Stand 9

Plot Number	Number EM/acre
23	1,280
24	80
25	0
EM/acre range = 0-1,280 EM/acre average = 340	EM size range (mm) = 30-35 EM size average (mm) = 31

Stand 10

Plot Number	Number EM/acre	Plot Number	Number EM/acre
26	1,680	28	1,280
27	360	29	80
EM/acre range = 0-1,680 EM/acre average = 850		EM size range (mm) = 30-38 EM size average (mm) = 34	

Stand 11

Plot Number	Number EM/acre
30	2,800
31	240
EM/acre range = 240-2,800 EM/acre average = 1,540	EM size range (mm) = 30-33 EM size average (mm) = 32

Stand 12

Plot Number	Number EM/acre	Plot Number	Number EM/acre
32	200	38	280
33	4,840	39	680
34	2,960	40	1,080
35	5,240	41	320
36	7,160	42	280
37	2,600		
EM/acre range = 280-7,160 EM/acre average = 2,331		EM size range (mm) = 27-32 EM size average (mm) = 30	

Stand 13

Plot Number	Number EM/acre	Plot Number	Number EM/acre
43	0	46	7,400
44	0	47	4,760
45	0	48	5,160
EM/acre range = 0-7,400 EM/acre average = 2,887		EM size range (mm) = 29-33 EM size average (mm) = 31	

Stand 21

Plot Number	Number EM/acre
49	0
50	0
EM/acre average = 0	

Stand 23

Plot Number	Number EM/acre
51	160
52	120
EM/acre range = 120-160 EM/acre average = 140	EM size range (mm) = 26-32 EM size average (mm) = 29

Stand 27

Plot Number	Number EM/acre
53	1,640
54	360
55	720
EM/acre range = 360-1,640 EM/acre average = 907	EM size range (mm) = 26-30 EM size average (mm) = 28

Stand 29

Plot Number	Number EM/acre	Plot Number	Number EM/acre
56	7,840	58	3,120
57	1,440	59	2,560
EM/acre range = 1,440-7,840 EM/acre average = 3,740		EM size range (mm) = 24-36 EM size average (mm) = 30	

Stand 32

Plot Number	Number EM/acre
60	0
61	0
62	0
EM/acre average = 0	

Stand 33

Plot Number	Number EM/acre
63	2,280
64	3,560
EM/acre range = 2,280-3,560 EM/acre average = 2,920	EM size range (mm) = 26-34 EM size average (mm) = 29

Stand 34

Plot Number	Number EM/acre
65	3,520
66	1,160
67	3,320
EM/acre range = 1,160-3,520 EM/acre average = 2,667	EM size range (mm) = 26-38 EM size average (mm) = 30

Stand 35

Plot Number	Number EM/acre	Plot Number	Number EM/acre
68	4,120	71	3,520
69	2,760	72	3,120
70	8,120	73	2,480
EM/acre range = 2,760-8,120 EM/acre average = 4,020		EM size range (mm) = 22-40 EM size average (mm) = 31	

Stand 37

Plot Number	Number EM/acre	Plot Number	Number EM/acre
74	1,360	77	5,880
75	520	78	5,080
76	1,680		
EM/acre range = 520-5,880 EM/acre average = 2,904		EM size range (mm) = 24-38 EM size average (mm) = 30	

Stand 38

Plot Number	Number EM/acre
79	760
80	80
EM/acre range = 80-760 EM/acre average = 420	EM size range (mm) = 28-32 EM size average (mm) = 30

Stand 39

Plot Number	Number EM/acre
81	120
82	40
83	480
EM/acre range = 40-480 EM/acre average = 213	EM size range (mm) = 26-30 EM size average (mm) = 28

Stand 40

Plot Number	Number EM/acre
84	0
85	0
EM/acre average = 0	

Stand 41

Plot Number	Number EM/acre
86	280
87	240
88	200
EM/acre range = 200-280 EM/acre average = 240	EM size range (mm) = 24-40 EM size average (mm) = 32

Stand 44

Plot Number	Number EM/acre
89	0
90	0
EM/acre average = 0	

Stand 51

Plot Number	Number EM/acre
185	120
186	2,200
187	1,040
EM/acre range = 120-2,200 EM/acre average = 1,120	EM size range (mm) = 24-30 EM size average (mm) = 27

Stand 56

Plot Number	Number EM/acre	Plot Number	Number EM/acre
91	0	93	0
92	0	94	0
EM/acre average = 0			

Stand 57

Plot Number	Number EM/acre
95	0
96	0
EM/acre average = 0	

Stand 58

Plot Number	Number EM/acre
97	0
98	0
99	0
EM/acre average = 0	

Stand 60

Plot Number	Number EM/acre	Plot Number	Number EM/acre
100	0	103	0
101	0	104	0
102	0		
EM/acre average = 0			

Stand 61

Plot Number	Number EM/acre	Plot Number	Number EM/acre
105	0	109	120
106	0	110	0
107	0	111	0
108	40	112	0
EM/acre range = 0-120 EM/acre average = 20		EM size range (mm) = 28-30 EM size average (mm) = 29	

Rod

2000

USDA United States Department of Agriculture | Forest Service | Northeastern Area State and Private Forestry | 180 Canfield Street Morgantown, WV 26505- 3101

File Code: 3460
Date: February 7, 2001

Glen Carowan, Refuge Manager
USDI Fish and Wildlife Service
Chesapeake Marshlands National Wildlife Refuge Complex
2145 Key Wallace Drive
Cambridge, MD 21613

Dear Mr. Carowan:

Enclosed is the gypsy moth biological evaluation for Chesapeake Marshlands National Wildlife Refuge Complex conducted in January of 2001. Included is our recommendation of treatment for those areas where defoliation is predicted in order to protect the habitat of the Delmarva fox squirrel.

In brief, gypsy moth populations are sufficient to cause defoliation on approximately 1709 acres. Our recommendation is a single application of *Bacillus thuringiensis* variety *kurstaki* (*Btk*) on 270 acres and a double application on 1439 acres.

The 2000 gypsy moth suppression project at Chesapeake Marshlands National Wildlife Refuge Complex was fairly successful. Foliage protection was provided for 93 percent of the treatment area and only 21 percent of the treatment area needs to be retreated in 2001.

If you have any questions concerning this biological evaluation, please feel free to contact Rod Whiteman (304-285-1555) or Brad Onken (304-285-1546).

Similar to previous years, my staff will provide technical assistance during the aerial treatment operations.

Sincerely,

John W Hazel

JOHN W. HAZEL
Field Representative

Enclosure

cc: Tom Eagle, Forester, Chesapeake Marshlands NWR Complex
Allen Carter, Regional Forester, USDI F&WS
Bob Tichenor, MDA
Steve Tilley, MDA
Noel Schneeberger, AO

RLW/JWH/mae

Stand 62

Plot Number	Number EM/acre	Plot Number	Number EM/acre
113	320	116	0
114	200	117	0
115	120	118	0
EM/acre range = 0-320 EM/acre average = 107		EM size range (mm) = 32-38 EM size average (mm) = 36	

Stand 63

Plot Number	Number EM/acre	Plot Number	Number EM/acre
119	0	122	40
120	40	123	80
121	80		
EM/acre range = 0-80 EM/acre average = 48		EM size range (mm) = 34-38 EM size average (mm) = 36	

Stand 64

Plot Number	Number EM/acre	Plot Number	Number EM/acre
124	120	127	6,920
125	360	128	160
126	7,000		
EM/acre range = 120-7,000 EM/acre average = 2,912		EM size range (mm) = 30-31 EM size average (mm) = 30	

Stand 65

Plot Number	Number EM/acre	Plot Number	Number EM/acre
129	40	132	0
130	0	133	0
131	0	134	40
EM/acre range = 0-40 EM/acre average = 13		EM size range (mm) = 26-30 EM size average (mm) = 28	

Stand 66

Plot Number	Number EM/acre	Plot Number	Number EM/acre
135	320	140	6,840
136	2,230	141	6,720
137	1,920	142	2,880
138	1,800	143	0
139	0	144	5,600
EM/acre range = 0-6,840 EM/acre average = 2,840		EM size range (mm) = 15-45 EM size average (mm) = 29	

Stand 67

Plot Number	Number EM/acre	Plot Number	Number EM/acre
145	80	151	680
146	880	152	680
147	280	153	380
148	200	154	600
149	40	155	160
150	0	156	0
EM/acre range = 0-880 EM/acre average = 357		EM size range (mm) = 28-42 EM size average (mm) = 38	

Stand 68

Plot Number	Number EM/acre	Plot Number	Number EM/acre
157	560	159	1,280
158	240	160	240
EM/acre range = 240-1,280 EM/acre average = 580		EM size range (mm) = 24-32 EM size average (mm) = 28	

Stand 69

Plot Number	Number EM/acre	Plot Number	Number EM/acre
161	360	163	240
162	360	164	1,280
EM/acre range = 240-1,280 EM/acre average = 560		EM size range (mm) = 20-50 EM size average (mm) = 35	

Stand 70

Plot Number	Number EM/acre
165	5,480
166	1,720
EM/acre range = 1,720-5,480 EN/acre average = 3,600	EM size range (mm) = 26-29 EM size average (mm) = 28

Stand 71

Plot Number	Number EM/acre	Plot Number	Number EM/acre
167	4,320	169	720
168	3,360	170	4,080
EM/acre range = 720-4,320 EM/acre average = 3,120		EM size range (mm) = 20-30 EM size average (mm) = 25	

Stand 72

Plot Number	Number EM/acre	Plot Number	Number EM/acre
171	1,560	174	6,440
172	1,640	175	4,320
173	1,880	176	5,760
EM/acre range = 1,560-6,440 EM/acre average = 3,600		EM size range (mm) = 20-34 EM size average (mm) = 27	

Stand 73

Plot Number	Number EM/acre	Plot Number	Number EM/acre
177	2,040	179	1,880
178	760	180	1,320
EM/acre range = 760-2,040 EM/acre average = 1,500		EM size range (mm) = 26-34 EM size average (mm) = 29	

Stand 74

Plot Number	Number EM/acre	Plot Number	Number EM/acre
181	6,360	183	3,800
182	3,760	184	7,880
EM/acre range = 3,760-7,880 EM/acre average = 5,450		EM size range (mm) = 24-29 EM size average (mm) = 26	

Table 2 – Comparison of pre-treatment and post-treatment egg mass densities at Chesapeake Marshlands NWR Complex.

Stand Number	Average EM/acre 1999 (pre-treatment)	Average EM/acre 2000 (post-treatment)	Percent Change
4	2,248	5,896	+ 162
5	1,288	27	- 98
6	1,791	168	- 91
7	1,740	370	- 79
9	3,693	340	- 91
39	867	213	- 75
51	2,187	1,040	- 52
All treated Stands	1,973	1,150	- 42

Table 3 – Projected defoliation levels for each surveyed stand at Chesapeake Marshlands NWR Complex in 2001.

Stand Number	Projected Defoliation	
	Percent Defoliation	Defoliation Class
4	80%	Heavy
13	71%	Heavy
29	79%	Heavy
33	68%	Heavy
34	65%	Heavy
35	79%	Heavy
37	69%	Heavy
64	69%	Heavy
66	66%	Heavy
70	78%	Heavy
71	64%	Heavy
72	77%	Heavy
74	81%	Heavy
3	33%	Moderate
7*	44%	Moderate
10	34%	Moderate
11	46%	Moderate
12	59%	Moderate
27	32%	Moderate
51	34%	Moderate
69	31%	Moderate
73	42%	Moderate
1	6%	Light
5	5%	Light
6	13%	Light
9	26%	Light
23	10%	Light
38	27%	Light
39	12%	Light
41	18%	Light
61	2%	Light
62	8%	Light
63	5%	Light
65	1%	Light
67	27%	Light
68	28%	Light

No defoliation (zero percent) is expected in stands 21, 32, 40, 44, 56, 57, 58, 60 and most of 7.

* = South western portion.

Figure 1. -- Stands surveyed for gypsy moth egg masses at Chesapeake Marshlands NWR Complex, January 8-11, 2001.

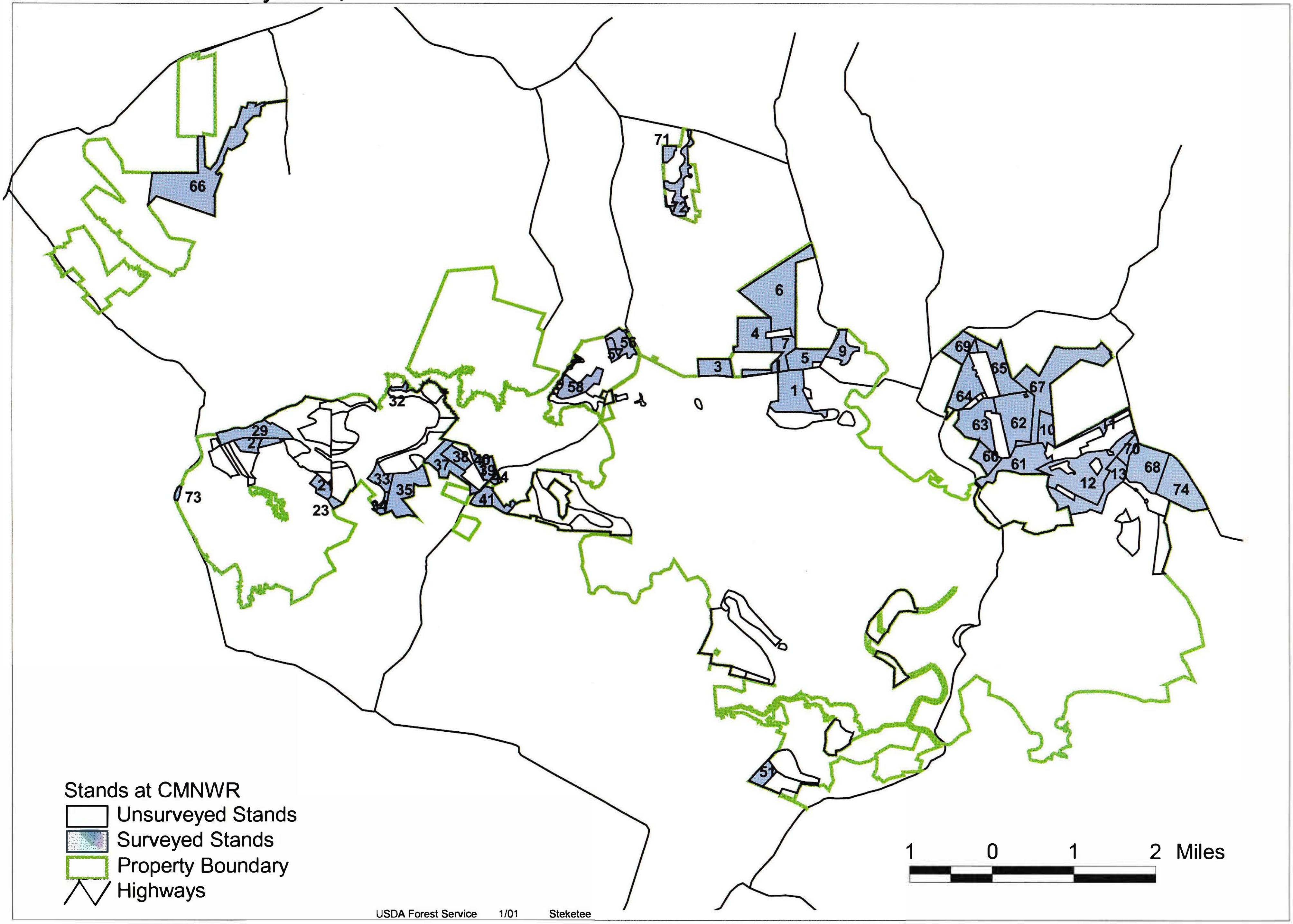


Figure 2a. -- Gypsy moth egg mass survey plot locations at Chesapeake Marshlands NWR Complex, January 8-11, 2001 (North Side and Southern Stand).

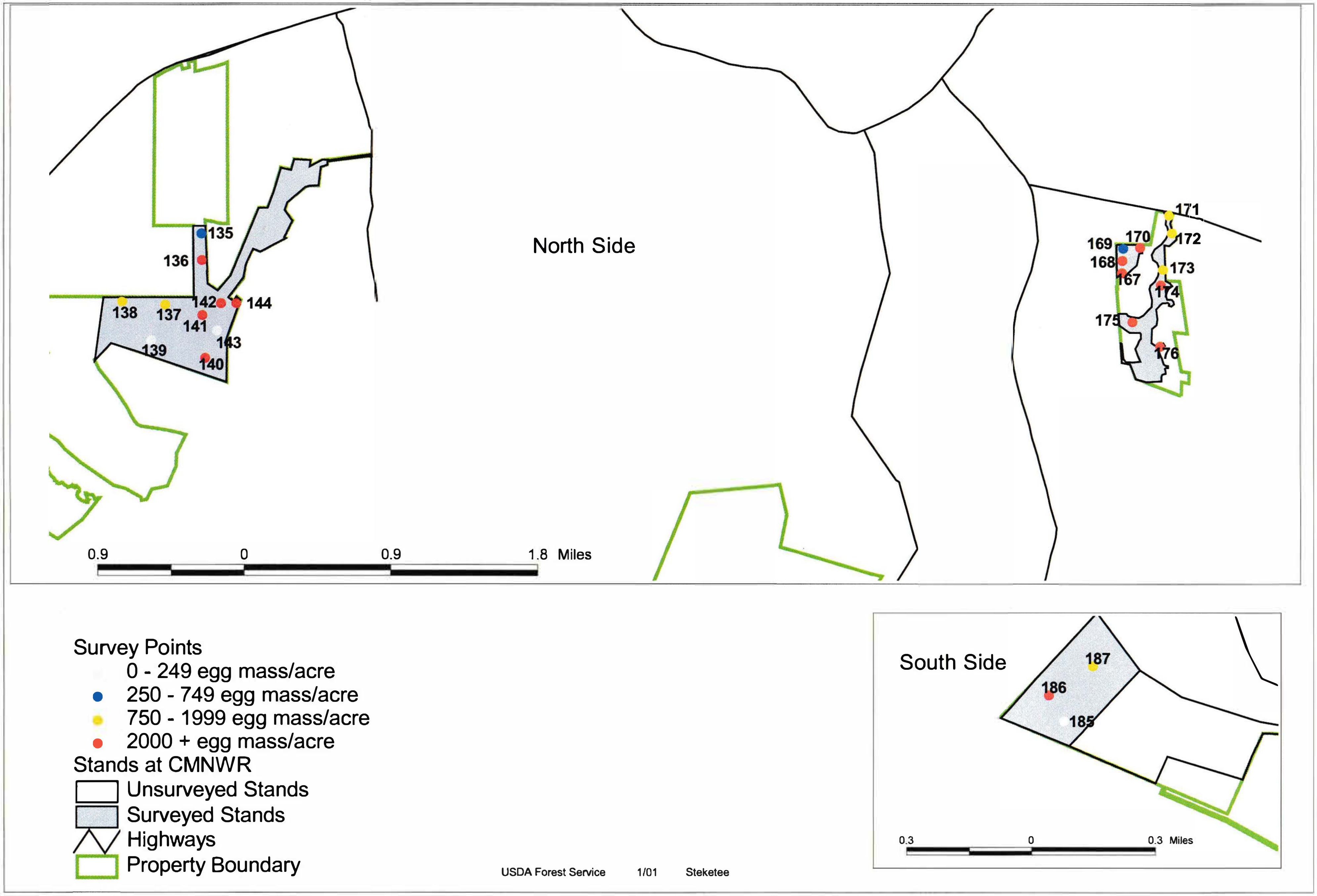


Figure 2b. -- Gypsy moth egg mass survey plot locations at Chesapeake Marshlands NWR Complex, January 8-11, 2001 (West Side).

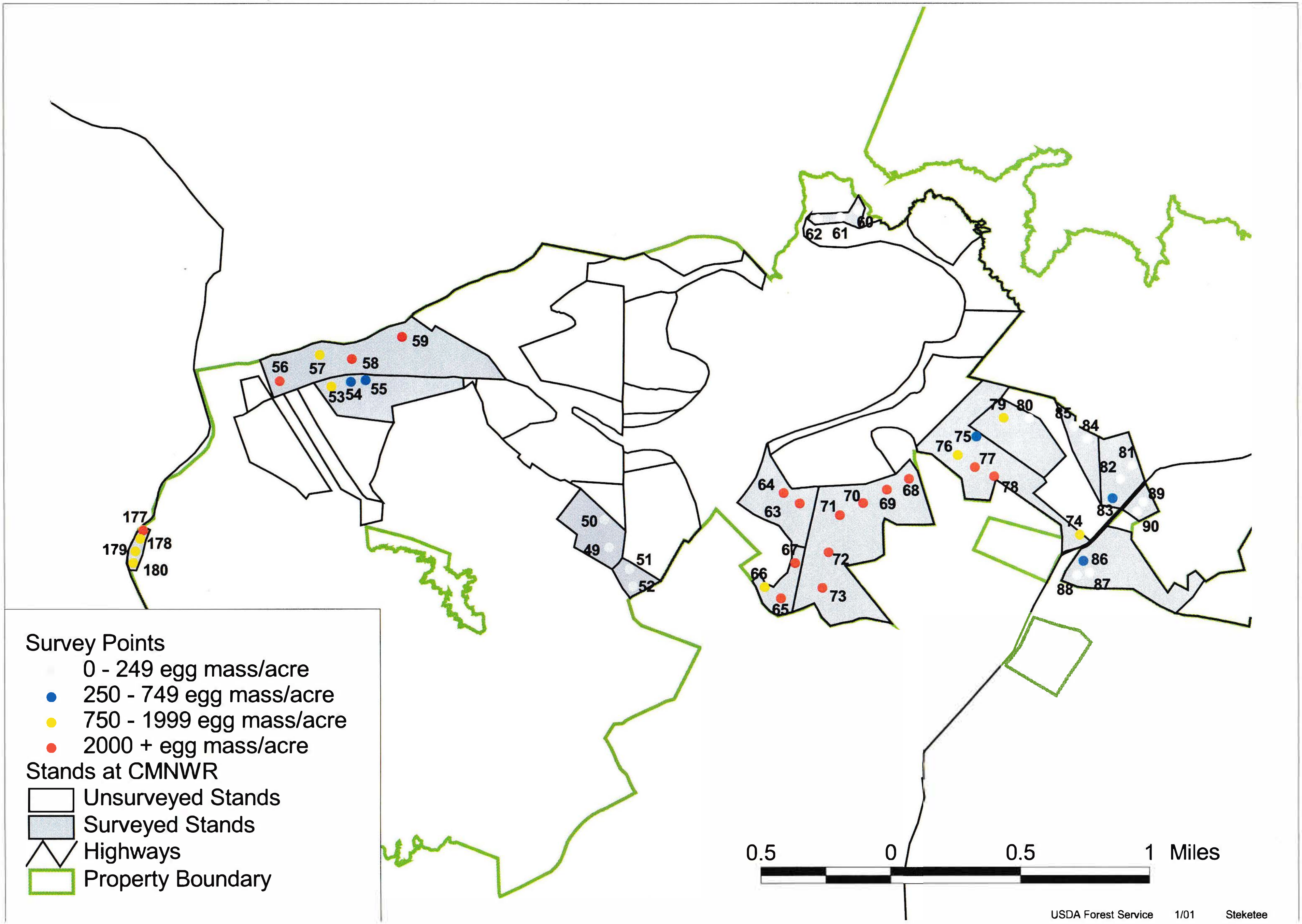


Figure 2c. -- Gypsy moth egg mass survey plot locations at Chesapeake Marshlands NWR Complex, January 8-11, 2001 (Center).

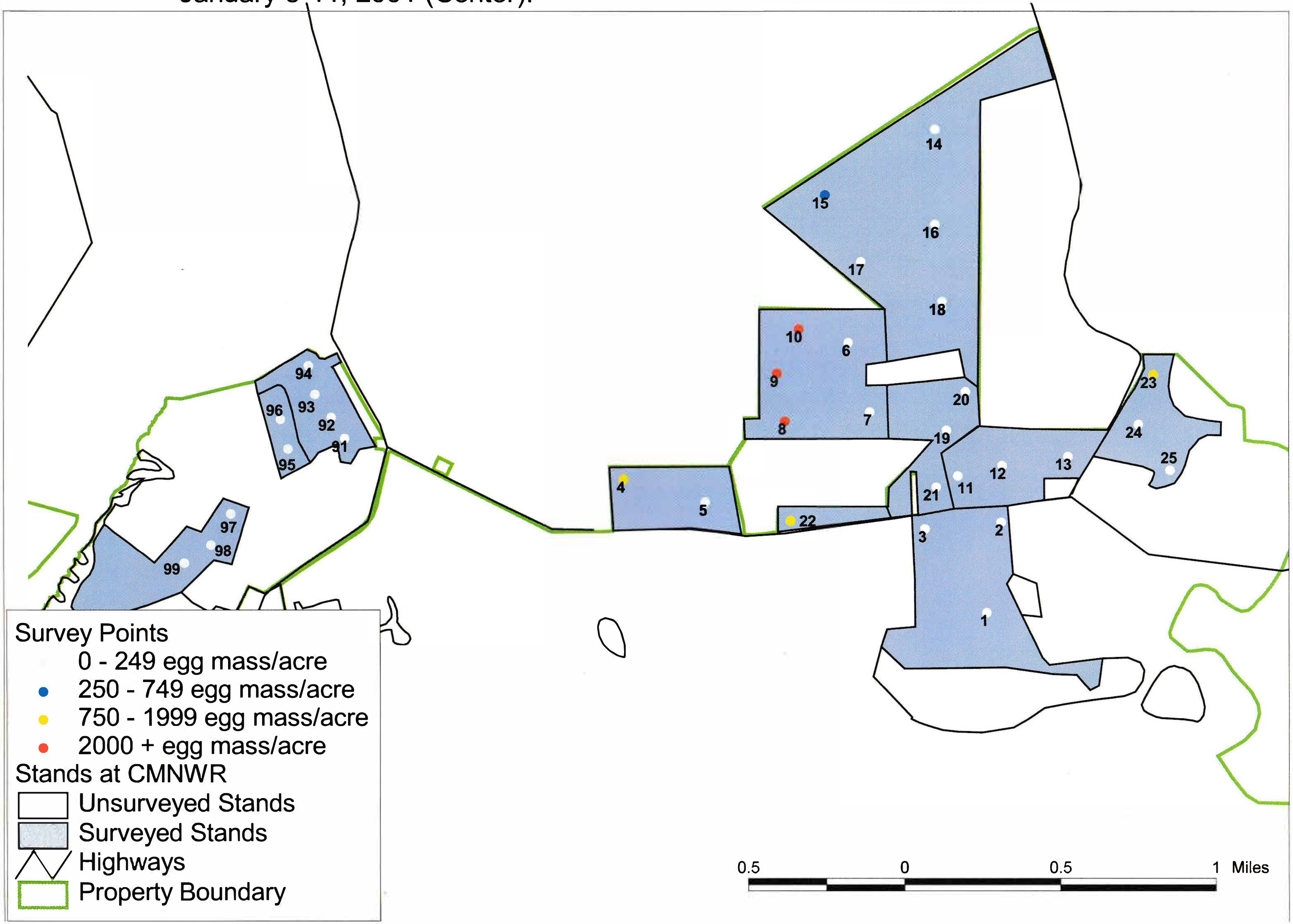


Figure 2d. -- Gypsy moth egg mass survey plot locations at Chesapeake Marshlands NWR Complex, January 8-11, 2001 (East Side).

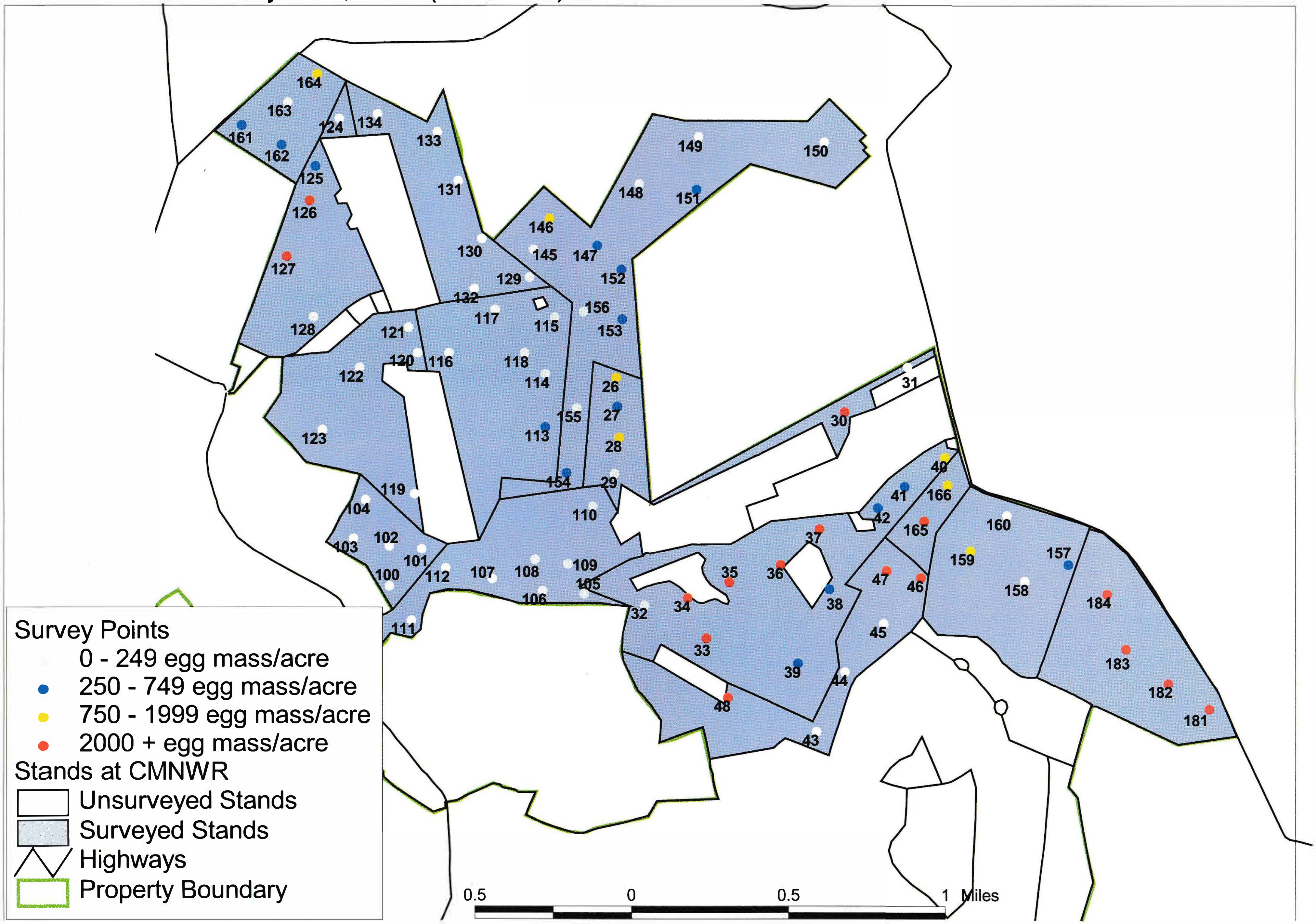


Figure 3.--Results of the gypsy moth defoliation survey conducted at Chesapeake Marshland National Wildlife Refuge on June 20 and the 2000 gypsy moth treatment blocks.

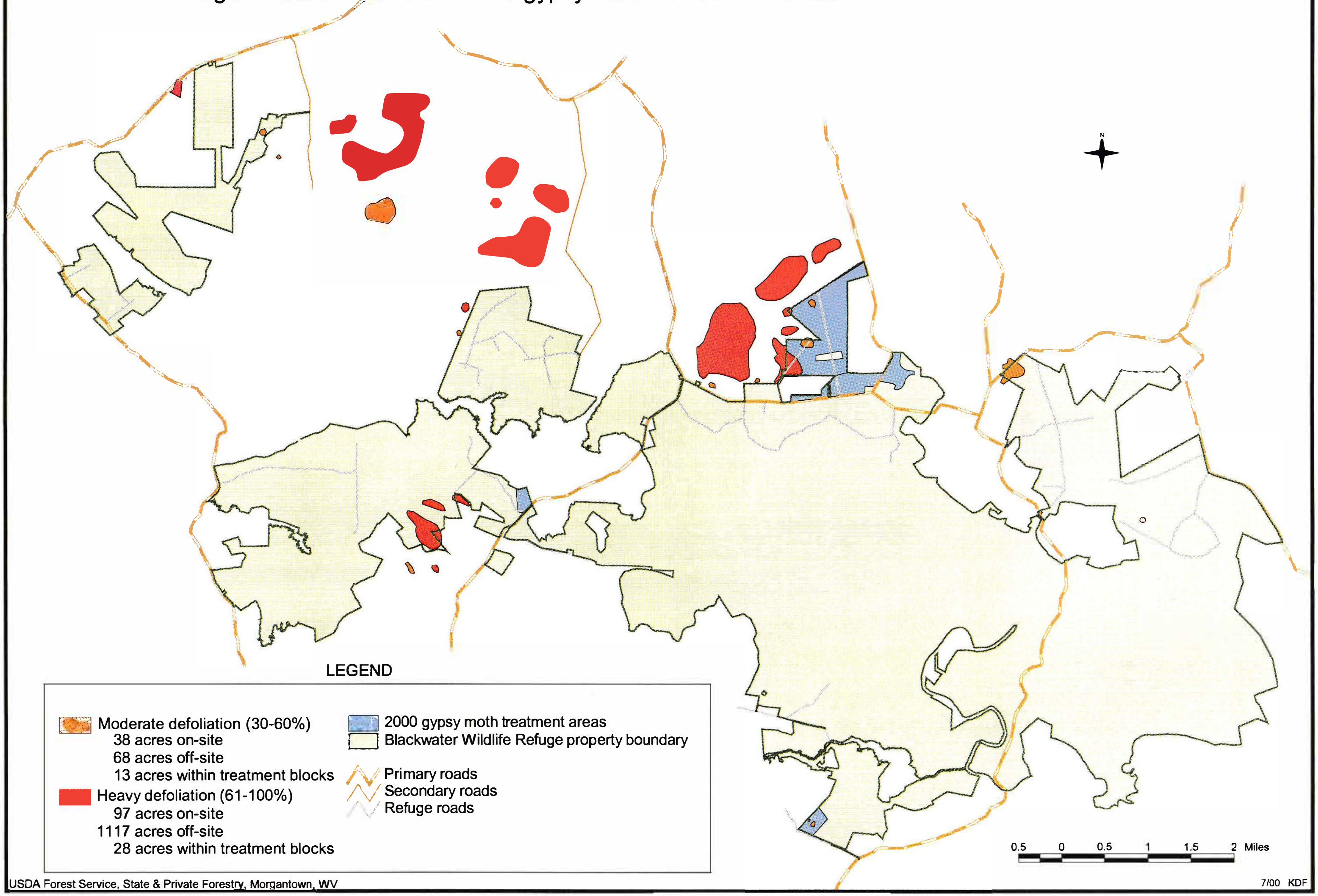
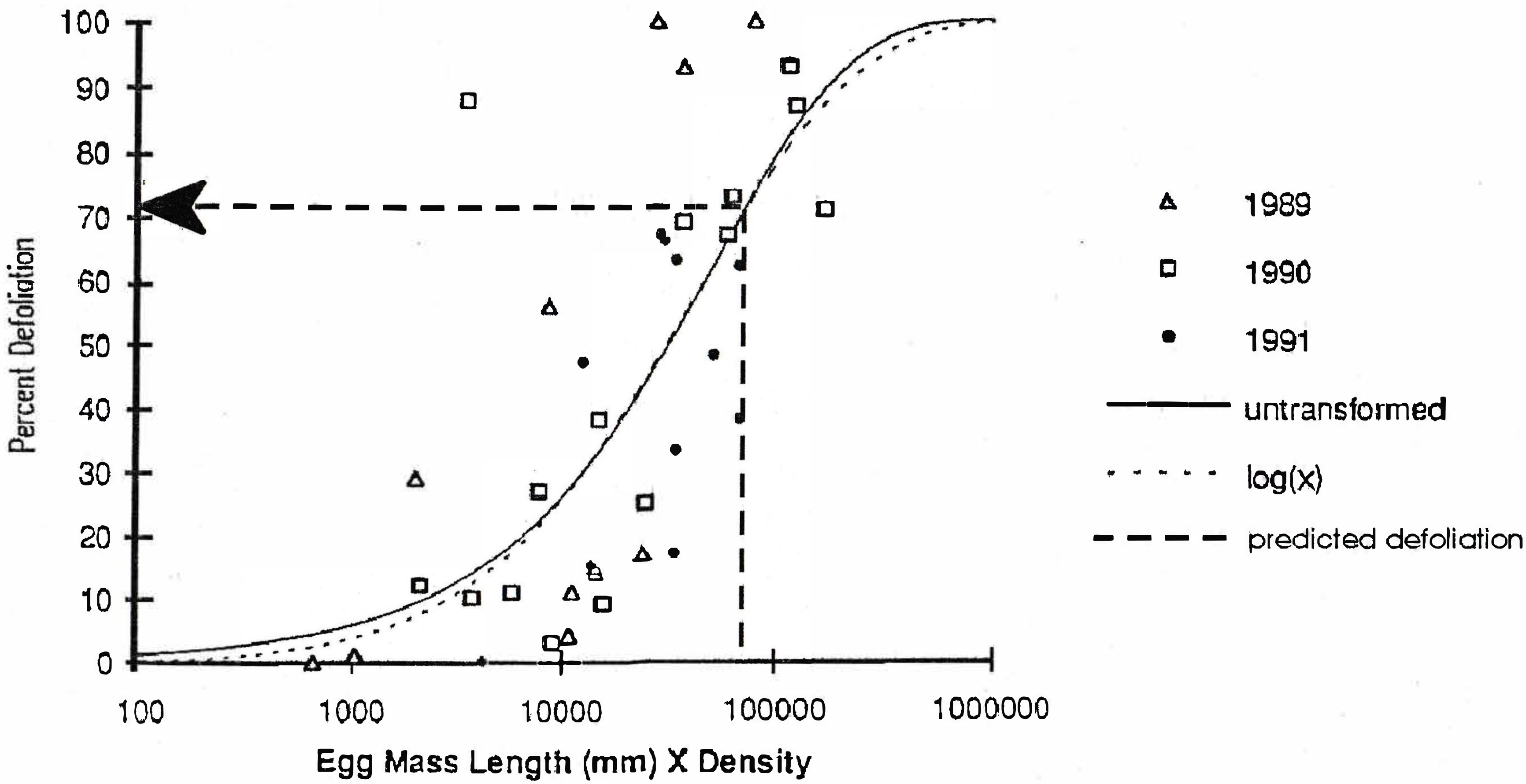


Figure 4.--Predicted defoliation in stand 13 in 2001 based on egg mass length and density.



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation. Extracted from Liebhold et al. (1993).

Figure 5. -- Recommended gypsy moth treatment blocks at Chesapeake Marshlands NWR Complex in 2001.